Data Monitor for Märklin Model Railway Systems

pulse packets on the PC monitor

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Regardless of whether they're generated by DELTA Control, Control Unit, Digital Railrunner, EEDTS Pro or something else, digital locomotive control signals in the 'Motorola format' all look pretty much alike on the rails. If you want to view these signals live on a PC monitor, you need the data monitor described in this article.

The Märklin digital control protocol has already been described a good number of times (for instance, in the May 1999 issue of *Elektor Electronics*). We can thus limit our description of the theory to the bare essentials. The data are transmitted in the form of pulse packets consisting of 18 individual pulses or 9 pulse pairs. The voltage levels on the rails that are used to transmit the pulses are approximately –15 V and +15 V, with the exact values varying according to the control unit used and the degree to which it is loaded by the connected devices.

Depending on the situation, an individual pulse is interpreted as a bit, while a pulse pair (consisting of two individual pulses) is interpreted as a 'trit' (trinary bit). The associated logical value is encoded by the duty factor of the signals or the pulse width of a particular pulse. In the digital data stream on the rails, the bits and trits have the following forms:

bit '0'
26 μs at +15 V, 182 μs at –15 V

bit '1'
182 μs at +15 V, 26 μs at –15 V

trit '0'
26 μs at +15 V, 182 μs at –15 V
26 μs at +15 V, 182 μs at –15 V

trit '1'
182 μs at +15 V, 26 μs at –15 V
182 μs at +15 V, 26 μs at –15 V

trit 'open'
182 μs at +15 V, 26 μs at –15 V
26 μs at +15 V, 182 μs at –15 V

In the old Motorola format, a complete pulse packet consists of four trits for the locomotive address, one trit for the 'Function' function and four trits for the speed, including changing direction. In the new Motorola format, the last four trits are replaced by eight bits for the speed, directional information and functions f1, f2, f3 and f4. The pulse packets thus have the same lengths in both formats, namely approximately 3.75 ms.

For the Data Monitor, the signal from the booster that is present on the rails is connected to the serial interface of the PC after undergoing a level adjustment. The Data Monitor program then samples the signal present at the serial interface at quite short intervals for the duration of the measurement interval (several seconds) and stores the results. Following the completion of the measurement, the measured values are evaluated and can then be displayed in detail on the PC screen.

The quality of the measurement is entirely dependent on the frequency and constancy of the sampling rate. Certain things must be taken into account in this process (as discussed further under 'Software'). With a constant sampling rate, at least two samples should fall within a relatively short pulse width of 26 μs in order to obtain a reasonable measurement result. This leads to a minimum sampling rate of around 83.5 kHz. Such a sampling rate can easily be achieved with a modern PC, even under Windows. On the author's PC, which has an Intel Celeron processor clocked at 466 MHz, a sampling rate of around 350 kHz was achieved.

The hardware: a voltage divider

The signal present on the rails is connected to the serial interface of a

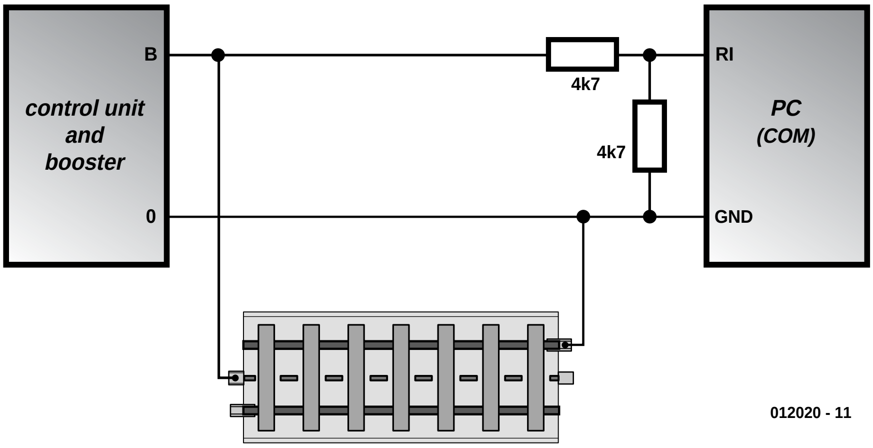


Figure 1. Connections and circuit diagram.

PC. Since voltages greater than 15 V can also be present on the rails, a voltage divider (**Figure 1**) consisting of two 4.7-kΩ resistors ensures that the levels arriving at the interface lie securely within the range specified by the RS232C/V.28 standard.

At the serial interface, the RI (Ring Indicator) and GND (Ground) leads are used. On a 25-way sub-D plug, RI is located on pin 22 and GND on pin 7, while on a 9-way sub-D plug RI is assigned to pin 9 and GND to pin 5. The two-wire cable to the PC may be relatively long without causing any problems, but you should be careful to maintain the correct polarity. In the Märklin scheme, terminal ‘B’ is connected to the middle pickup rail.

Please also note that due to the connection to the PC, the motive power circuit of the model railway is no longer floating, but instead is tied to earth via the GND connection. If this is not compatible with other circuits in your model facility, they must first be isolated from the motive power circuit.

Software

The Data Monitor program has been generated using Microsoft Visual Basic 5. Access to the serial interface is provided by the PORT.DLL dynamic linked library, which regular readers of *Elektor Electronics* already know from other projects (and which can be downloaded from the *Elektor Electronics* website).

User interface

As can be seen from **Figure 2**, the user interface is divided into five regions, as follows:

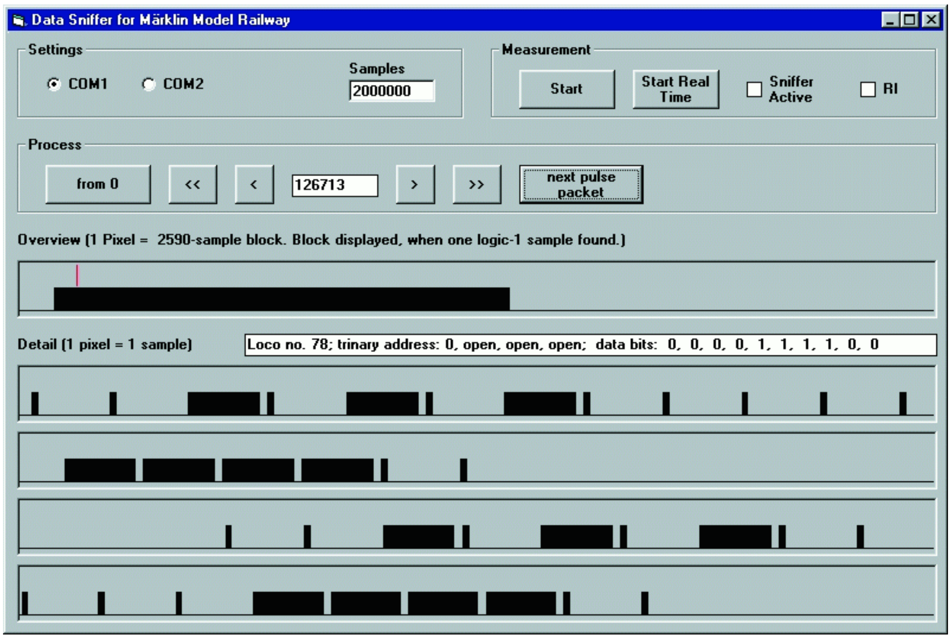
– Settings
This can be used to select the serial interface port and specify the number of samples for the measurement.

– Measurement
The Start button starts a measurement. The Start Realtime button also starts a measurement but disables interrupts during the measurement in order to prevent interference from other Windows processes, thereby increasing the quality of the measurement and the sampling rate. While the measurement is being made, the Monitor Active check box displays a tick mark. In between measurements, the RI check box shows the level on the RI lead using periodic sampling.

– Evaluation
The various buttons are used to control the detailed display. The number of the first displayed sample is also shown here. One special feature is the Next Pulse Packet button. This button positions the detailed display to the beginning of the next pulse packet (more precisely, just before the beginning) and then evaluates the content of this pulse packet. The result of the evaluation is then shown in text form at the top of the Detail display.

– Summary Display
The complete measurement is shown here, with the samples combined into blocks. If a ‘1’ is located within a block (this corresponds to the 15-V level), the block is displayed as active. A red line is also shown at the start of the current detail display location.

– Detail display
The Detail display shows the values of the individual samples in increasing sequence using four picture boxes. The first sample dis-



Data Sniffer for Märklin Model Railway

Settings: ● COM1 ○ COM2 Samples 2000000

Measurement: ☐ Sniffer Active ☐ RI

Process: 126713

Overview (1 Pixel = 2590-sample block. Block displayed, when one logic-1 sample found.)

Detail (1 pixel = 1 sample) Loco no. 78; trinary address: 0, open, open, open; data bits: 0, 0, 0, 0, 1, 1, 1, 1, 0, 0

Figure 2. The user interface of the Data Monitor program, showing a pulse packet in the ‘old’ Motorola format for locomotive number 78.

played can be controlled using the Evaluation button in the controls region. There are always 3088 samples visible.

The figure shows a pulse packet in the old Motorola format for locomotive number 78. The displayed data bits (0000111100) or data trits (00110) mean that Function is 'off' and the Speed is '6'. The display begins with sample 130297 of a total of 2,000,000 samples. The entire measurement for this example took around six seconds.

Special features and system requirements

In order to obtain reliable measurements, the Start Realtime button should normally be used. This disables the maskable interrupts during the measurement interval and thus minimises disturbances by other Windows processes. During the measurement process, all other actions that create work for the PC should also be avoided as much as possible — for example, moving the mouse.

The Data Monitor is available as a complete VB5 setup. This means that it is not necessary to install Visual Basic on the computer before using the program. The software can be downloaded free of charge from the *Elektor Electronics* webserver or obtained on diskette from Readers Services (order number **010202-11**). This applies to both the source code as well as the compiled PC program. As a special feature, the program has been complied in system code (native code) rather than P-code. This results in an increased sampling rate.

The Data Monitor requires a PC with a free serial port (COM1 or COM2) and Microsoft Windows 95, 98, NT 4.0 or 2000 as the operating system. The program should run properly on all computers with a clock rate of around 200 MHz or greater.

The motive power circuit of the railway, or the output of the controller or booster, must either be floating with respect to earth or tied to earth via the track lead (not the middle pickup rail lead!).

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Literature and Internet addresses:

Digital Control for Model Trains, *Elektor Electronics*, May 1999.

Author's home page with other projects for model railways (including non-electronic projects): *www.koerber-home.de*